Insights from regional well integrity datasets: challenges and future opportunities

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Research Engineer, Research & Innovation Center

(Sabbatino et al., 2017)
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\end{itemize}
Regional well integrity testing

- Sustained casing pressure (SCP) and/or casing-vent flow (CVF)
  - Fluid flow in an annulus outside the production casing
  - Indicative of a barrier flaw or gas invasion into well
  - Not all wells with SCP/CVF leak into groundwater
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  - Not all wells with SCP/CVF leak into groundwater
- Regulatory agency and industry
- Routinely administered
- Publicly available
Canadian testing programs

- Alberta, British Columbia, and Saskatchewan
- Monitoring and management
  - CVF testing protocol
  - Serious and nonserious designation
  - Testing upon abandonment
- Leakage frequencies & trends

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<tr>
<th>Region</th>
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<td>AB</td>
<td>&gt;450,000</td>
<td>6.6%</td>
<td>Watson and Bachu, 2008; Bachu, 2017</td>
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<td>21,525</td>
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Testing programs in the US

- >900,000 active oil and gas wells
- SCP testing in the Gulf of Mexico

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**Project goal: build a bigger dataset for onshore wells**

(Sabbatino et al., 2017)
Patchwork of regulations

• Reviewed state databases
• Searched for:
  • SCP/CVF testing
  • Regional approach (100s-1,000s)
  • Publicly available records
• State programs that met criteria:
  • Colorado
  • New Mexico
  • Pennsylvania
Limited data availability

- Aggregated databases
- Document sorting
  - >575,000 documents
  - TensorFlow
- Text-based PDFs
- Image-based PDFs
  - >90,000 documents
  - Manual data entry web application
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Largest US oil and gas well integrity dataset: 474,621 tests from 105,031 oil and gas wells in PA, CO, & NM
Test interpretation

- Pressure and flow measurements
Test interpretation

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- CVF Definition
  - Any well with a nonzero flow in an annulus outside the production casing
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- Pressure and flow measurements
- CVF Definition
  - Any well with a nonzero flow in an annulus outside the production casing
- SCP Definition
  - API RP 90-2
  - Diagnostic threshold (DT) = 50 psi
SCP/CVF occurrence varies over a wide range

- **Colorado**
  - Denver-Julesburg – 26.5%*
  - Piceance – 21.3%*
  - San Juan – 19.2%
  - Raton – 0.3%

- **New Mexico**
  - San Juan – 9.9%
  - Raton – No data
  - Permian – 7.0%*

*Targeted testing in DJ, Piceance, and Permian Basins potentially skews percentages
Higher occurrence in PA than previously estimated

- Pennsylvania – 14.1% of tested wells
  - Northwest district – 10.7%
  - Southwest district – 14.2%
  - Eastern district – 22.2%
- Previous studies estimated 2.6-6.2% (Davies et al., 2014)
- Highest previous regional estimate: 10.8% in BC (Wisen et al., 2019)
Significant spatial variations

- Significant SCP/CVF variation between regions
  - E.g., San Juan Basin: 19.2%, Raton Basin: 0.3%
- Statistically significant hotspots within regions
SCP/CVF more common among directional wells

- SCP/CVF in 30.3% of directional wells
- SCP/CVF in 11.0% of vertical wells
- Trend observed in PA & CO but not NM
No trend of increased SCP/CVF among older wells

- Wells drilled after 2007 in PA reported an increased frequency of SCP/CVF
- Issues among older wells may be underreported
- Unconventional drilling may contribute to observed trend
Future challenges

- Dataset maintenance
- Changing websites and data reporting practices
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• Dataset expansion
  • Lack of information? Or lack of access?
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• Creation of a unified dataset
  • Reporting differences
    • E.g., negative test results in AB
  • Different testing standards
Future opportunities

- Characterizing environmental impacts

Reported Methane Emissions from Active Oil and Gas Wells in Pennsylvania, 2014–2018

Anthony R. Ingraffea*, Paul A. Wawrynek, Renee Santoro, and Martin Wells
Future opportunities

- Characterizing environmental impacts
- Understanding leakage trends
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- Characterizing environmental impacts
- Understanding leakage trends
- Leakage prediction and risk forecasting

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Anthony R. Ingraffea*, Paul A. Wawrzynek, Renee Santoro, and Martin Wells

Characterizing oil and gas wells with fugitive gas migration through Bayesian multilevel logistic regression
E. Sandil1, 2, A.G. Cahill3, L. Welch1, R. Beckie1
1 Earth, Climate, and Atmospheres, Science, University of British Columbia, 3330 Main Mall, Vancouver, BC V6T 1Z3, Canada
2 The Lyell Centre, Durham University, Science Centre South, Science Road Durham DH1 4HH, United Kingdom
3 British Columbia Oil and Gas Commission, 1090 Second Ave, Suite 1400, Vancouver, BC V6Z 1U5, Canada

Predicting gas migration through existing oil and gas wells
James A. Montague, George F. Pinder, and Theresa L. Watson
Conclusions

• Regional well integrity testing programs create valuable data that have significantly improved our understanding of well integrity

• Current datasets can be improved with:
  • Data from additional regions
  • More uniform testing and reporting guidelines/standards
  • A more streamlined protocol for gathering data from different regions

• Future opportunities:
  • Understanding well integrity issues and their impacts
  • Factors that influence integrity loss
  • Leakage prediction/risk forecasting
Data compatibility

Raw Data

Python scripts

Cleaning

Formatting

Quality Control

Uniform dataset
Testing variations

- **Colorado** – SCP testing since 1990
  - 115,468 tests on 22,108 wells
  - Biennial testing of CBM wells
  - Targeted testing in the DJ and Piceance
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  - Triennial testing in San Juan Basin
  - Targeted testing in Permian Basin
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- **Pennsylvania** – testing since 2014
  - 254,942 tests on 56,998 wells
  - Yearly testing of conventional wells
  - Quarterly testing of unconventional wells
Compliance issues

- Incomplete reporting
- Inconsistent use of flags
  - Ingraffea et al., 2020
- Dropped tests in data QC
Gas migration

- SCP buildup can result in groundwater contamination
Gas migration

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Gas migration

• SCP buildup can result in groundwater contamination
• Gas circumvention
Gas migration

- SCP buildup can result in groundwater contamination
- Gas circumvention
- Increased gas migration potential
  - CO: 3% of wells, NM: 0.1% of wells, PA: no data